Update on the CDX-U Liquid Lithium Limiter Experiments and LTX Status

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Summary

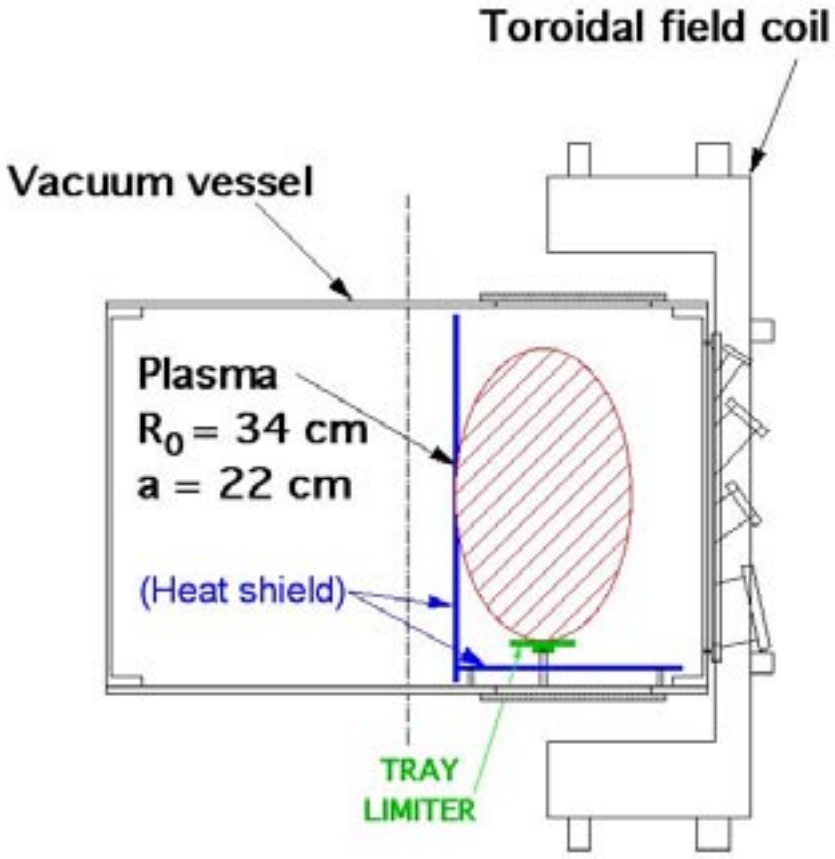
- Liquid lithium experiments on CDX-U have demonstrated
  - Low recycling
  - Impurity removal
  - Improved confinement
  - Increased stability with apparently broadened profiles
  - Efficient loop voltage utilization
- Latest issues have involved mechanical properties of liquid lithium
  - Stable in absence of toroidal current paths during plasmas
  - Challenge has been to control lithium migration in *long term* operation

Toroidal limiter tray designed with electrical break to insure mechanical stability of liquid lithium

CDX-U

LTX

- Limiter tray surface ≈ outermost flux surface
- Very low normal component of confining B-field
- Toroidal electrical break and single-point tray ground controls flow of current from plasma



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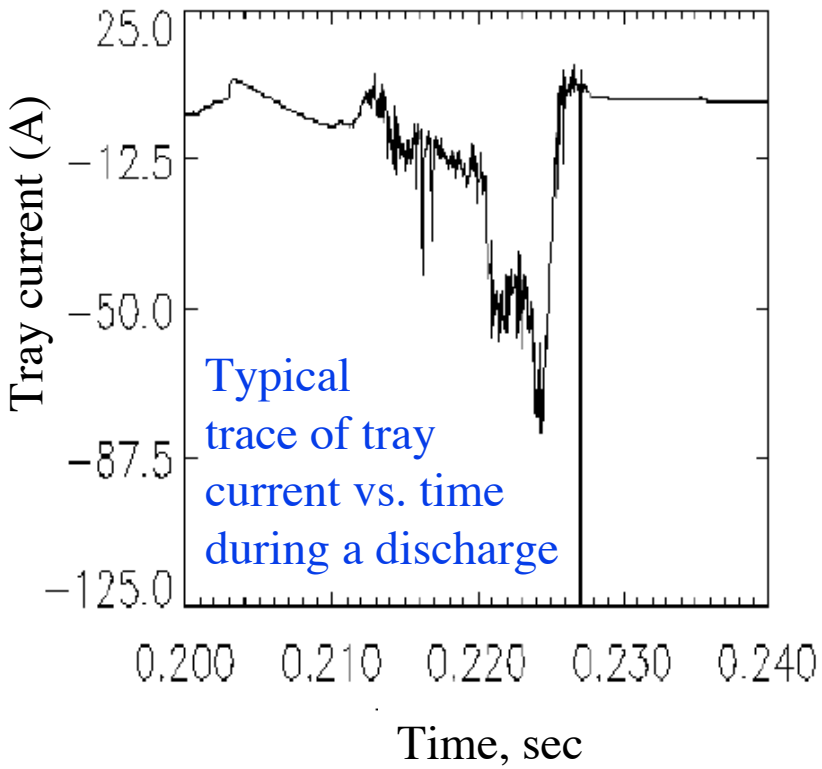
Liquid lithium mechanically stable with toroidal gap in limiter tray

CDX-U

LTX



- **No** motion of the liquid observed with fast camera
- **No** unipolar arcing
- **No** spatter, droplets, etc

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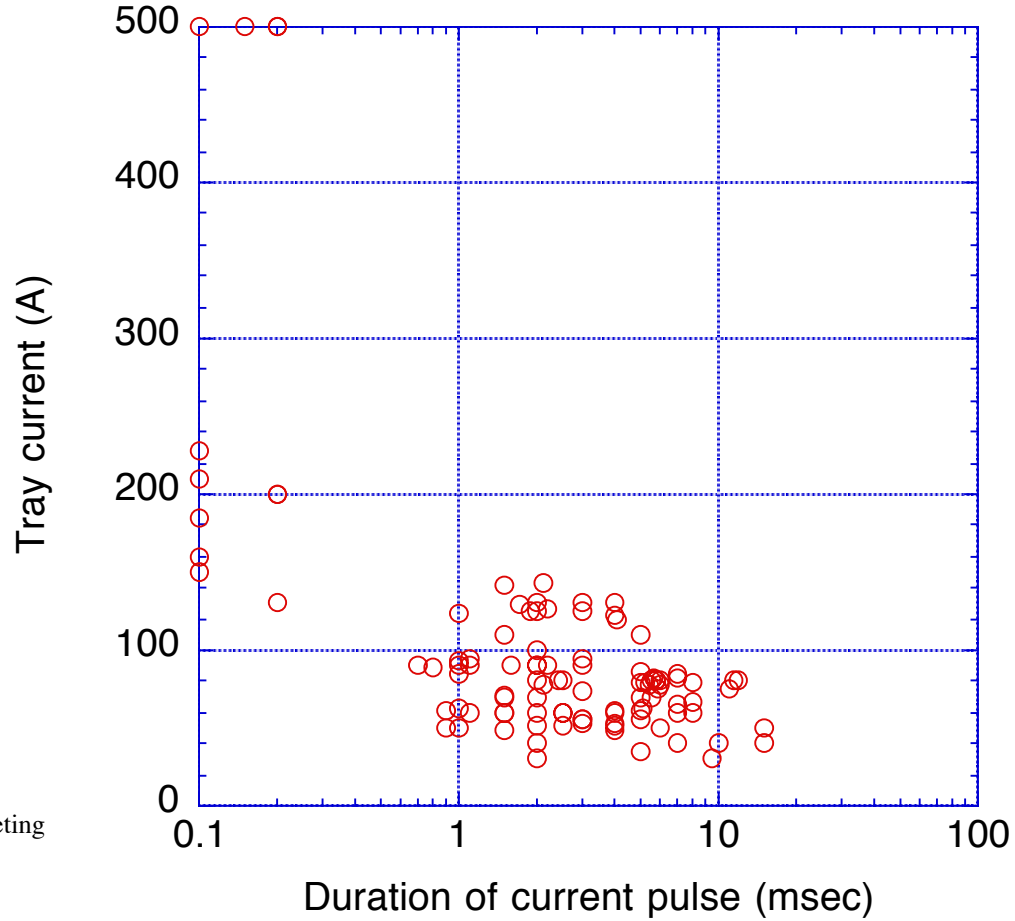
Mechanical stability persisted long enough for liquid lithium limiter experiments to be performed

CDX-U

LTX

- Lithium remained stable as current flowed to toroidally to ground
  - >70% of tray current flowed in liquid lithium
  - Current density commonly 20-30 A/cm^2 for several ms



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Tendency of liquid lithium to migrate eventually "shorted" toroidal gap in limiter tray

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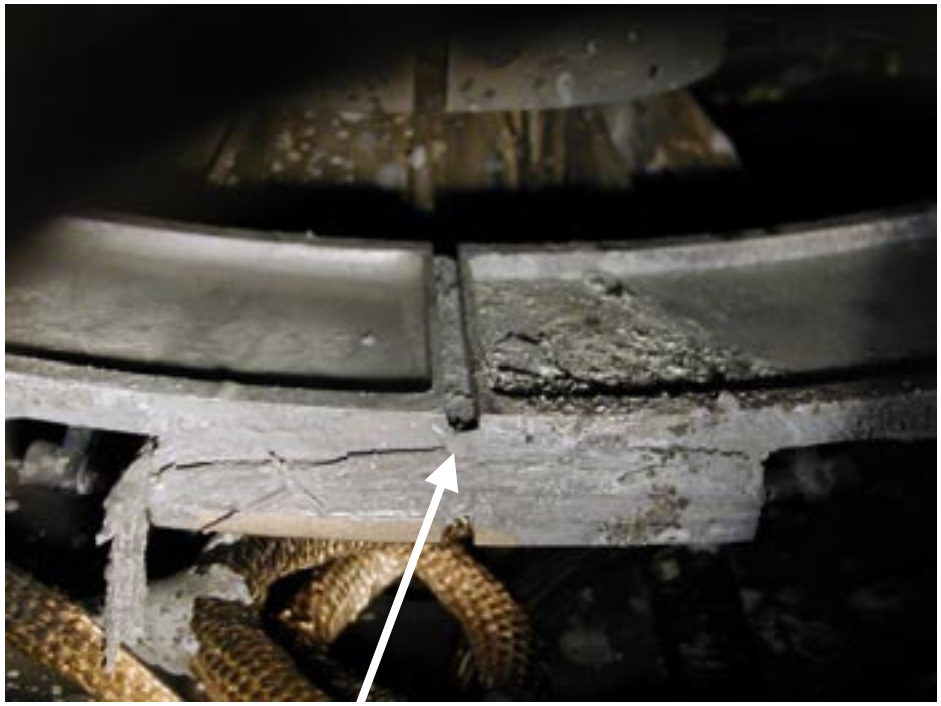
- Lithium migrated with time over tray edge
  - Glow discharge cleaning and tray heating permitted lithium flow



Toroidal gap shorted by migrating lithium

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Large B-normal component during *vacuum* shot ejected lithium after DC break was shorted

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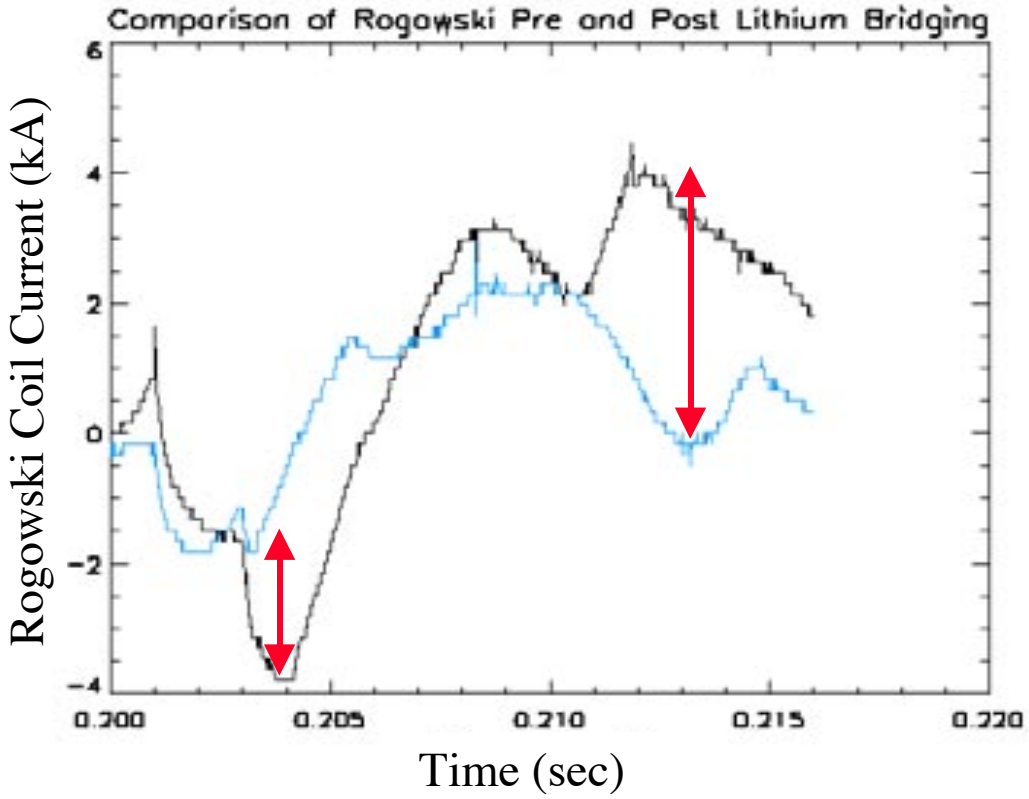
LTX

- Multi-kA toroidal current resulted in substantial jxB force on lithium
  - Lithium wet, bridged toroidal electrical break
  - OH swing induced ~5 kA in the lithium
  - *All lithium ejected*



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Lithium migration appears to depend on temperature

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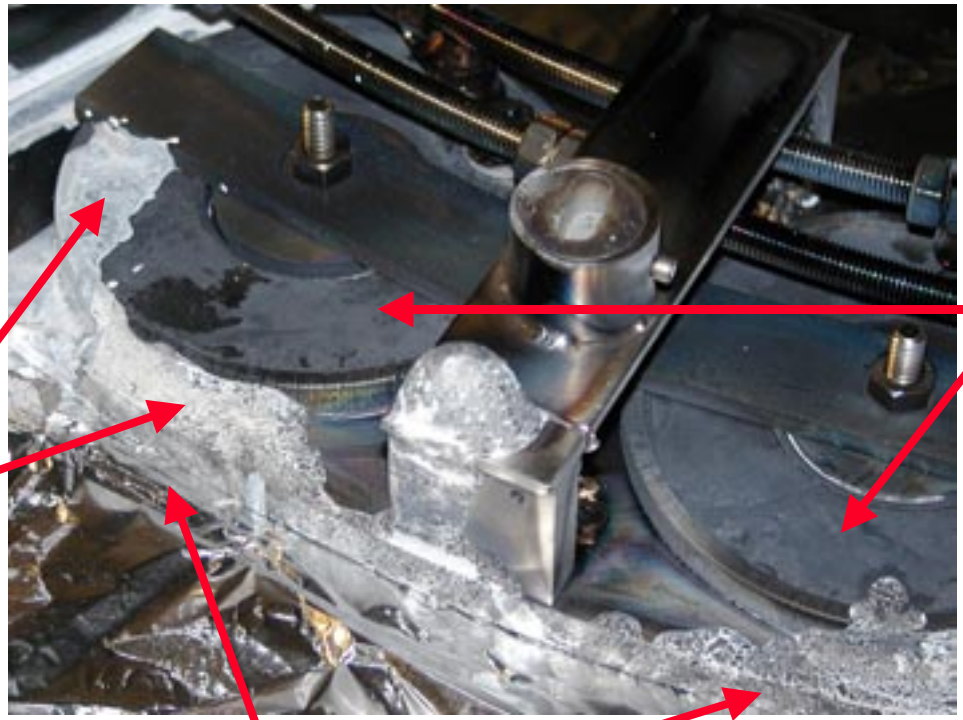
- Underside of tray shows more lithium where heaters are closest to edge of tray



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Solution was to modify heater configuration

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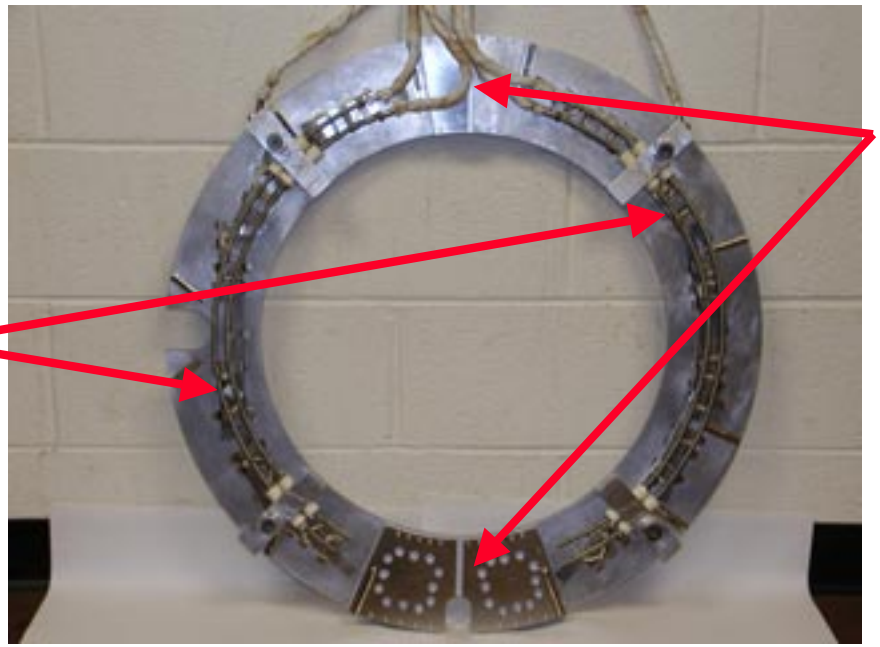
- Circular heaters replaced with new “strip” type located near center of tray



- Gaps between tray halves increased and heaters kept away from them

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New geometry successful in localizing lithium but problems with heaters ended campaign

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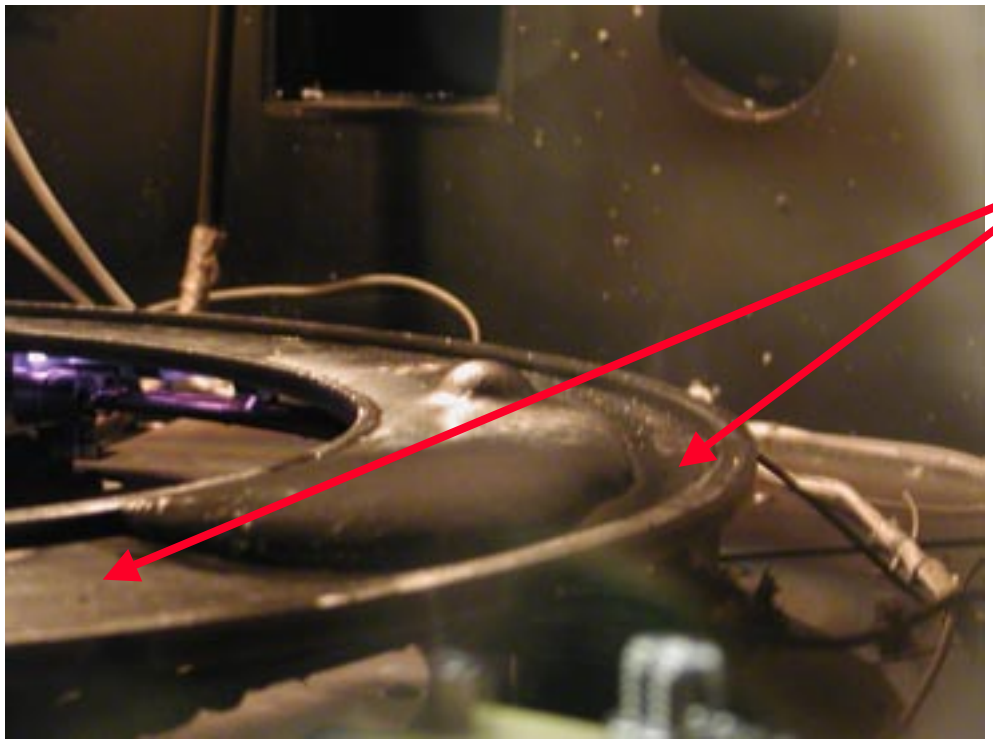
LTX



- More localized heating kept lithium away from edges of limiter tray

- Heaters failed shortly after most recent lithium fill in October 2004
  - Cause to be investigated after next vent

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Post-tray experiments

CDX-U

LTX

- Next phase will begin later in December or January
  - Operation with coated center stack
    - » Large plasma contact area expected to affect recycling
  - Coating source development nearing completion
    - » Presently looking at both resistively heated and e-beam lithium evaporation sources
- Expect to shut down for conversion to LTX in early 2005

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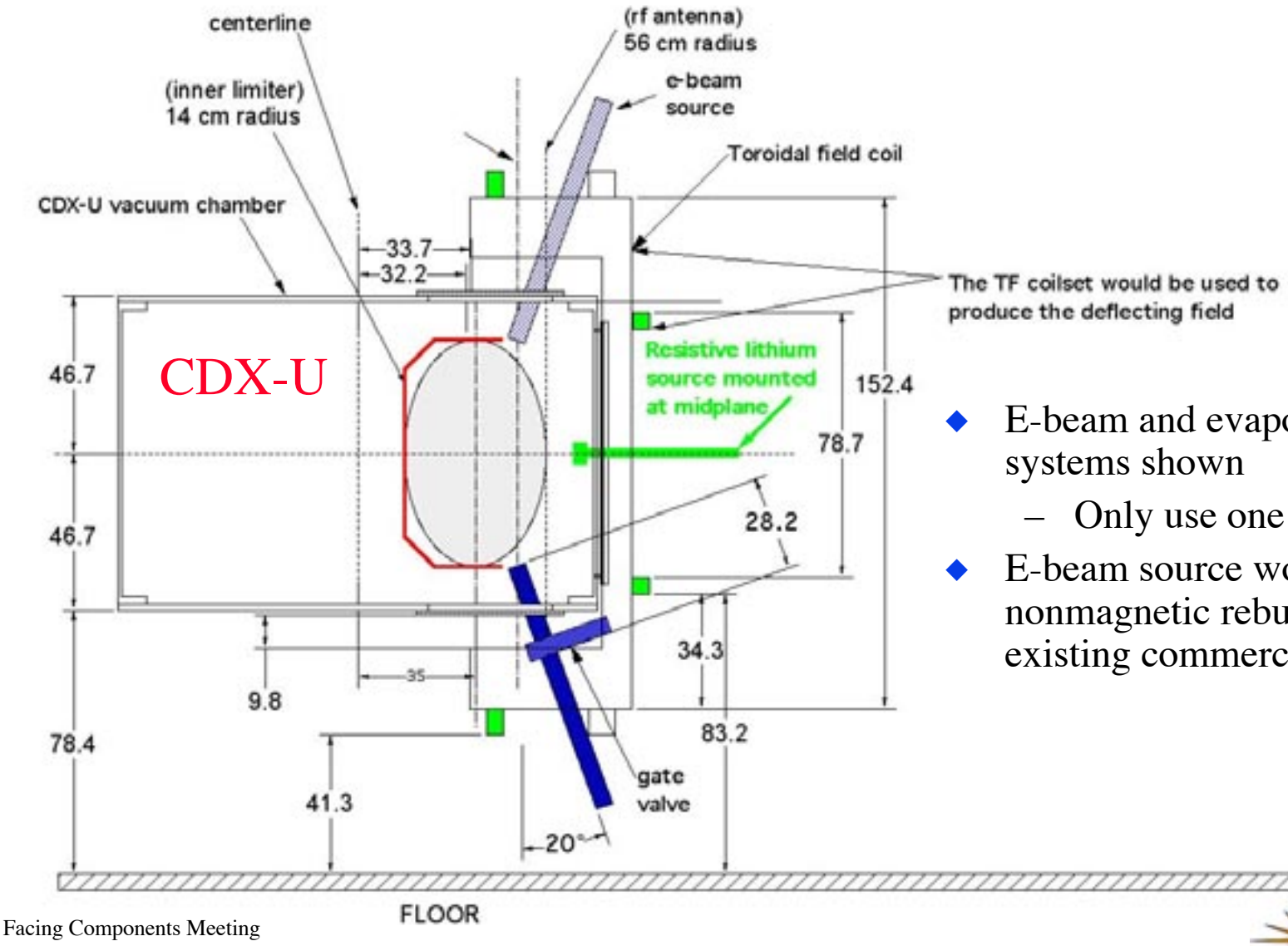
After the tray: tests of coated limiters for NSTX, LTX

(Winter 04) **CDX-U**



- E-beam and evaporative systems shown
  - Only use one!
- E-beam source would be nonmagnetic rebuild of existing commercial unit

Work begun on Lithium Tokamak Experiment (LTX)

CDX-U

LTX

- Physics Goals:
  - Access to novel tokamak regimes with very low recycling walls
    - » Broad/flat T_e, T_i profiles with no or small conduction losses
  - Control of the n_e, T_e, I_p profiles *with the fueling profile*

- Technical Features:
  - Conducting conformal shell
  - Evaporative coating on inner surface
    - » *Kept above lithium melting temperature to provide liquid lithium PFC*

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Design for LTX Conducting Shell Finalized

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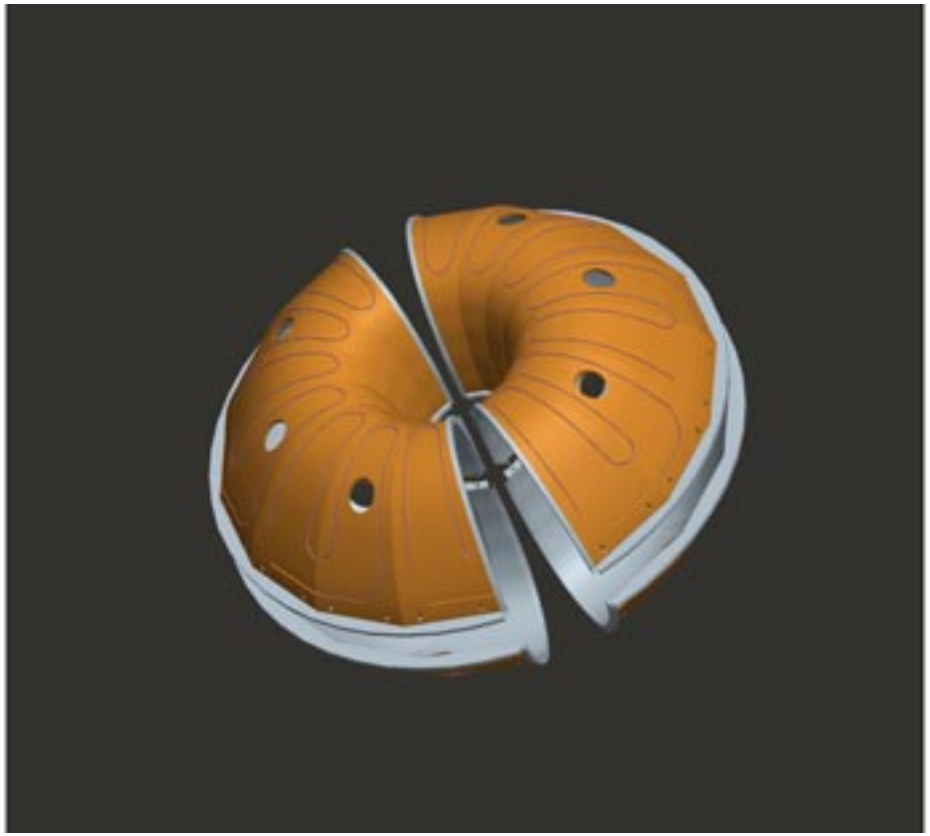
- Explosively bonded 0.062” layer of 304SS on 0.375” chromium copper

LTX



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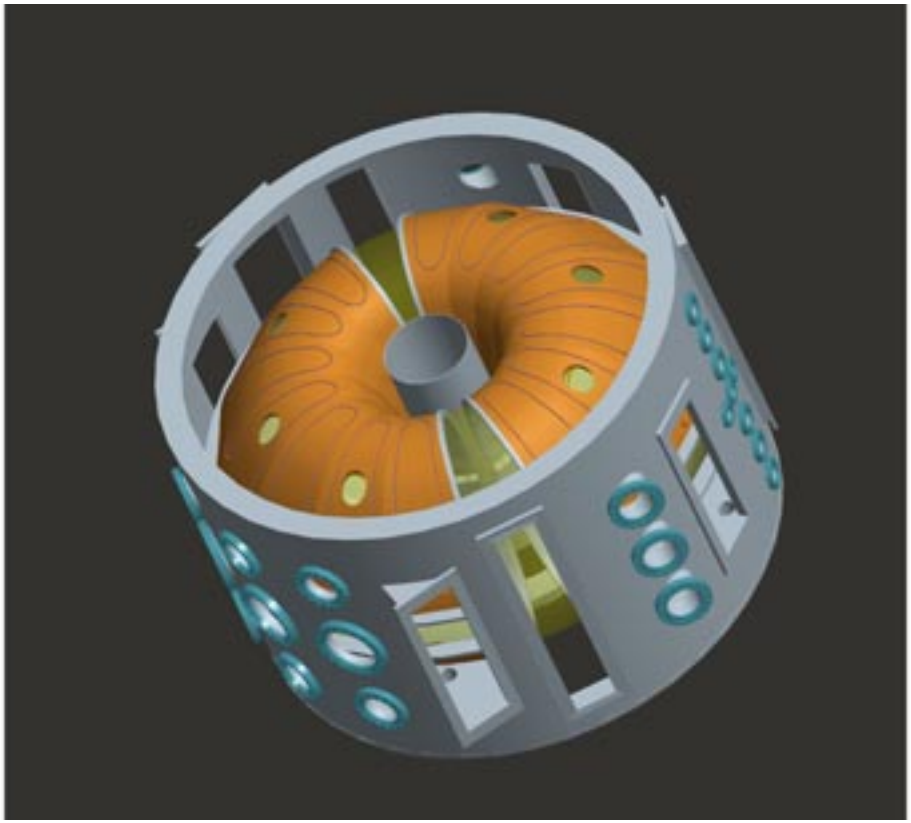
LTX Conducting Shell to fit in CDX-U Vacuum Vessel

CDX-U

LTX

- Shell is designed with toroidal, poloidal gaps
  - electrical breaks + diagnostic access
- Circular penetrations for coating systems



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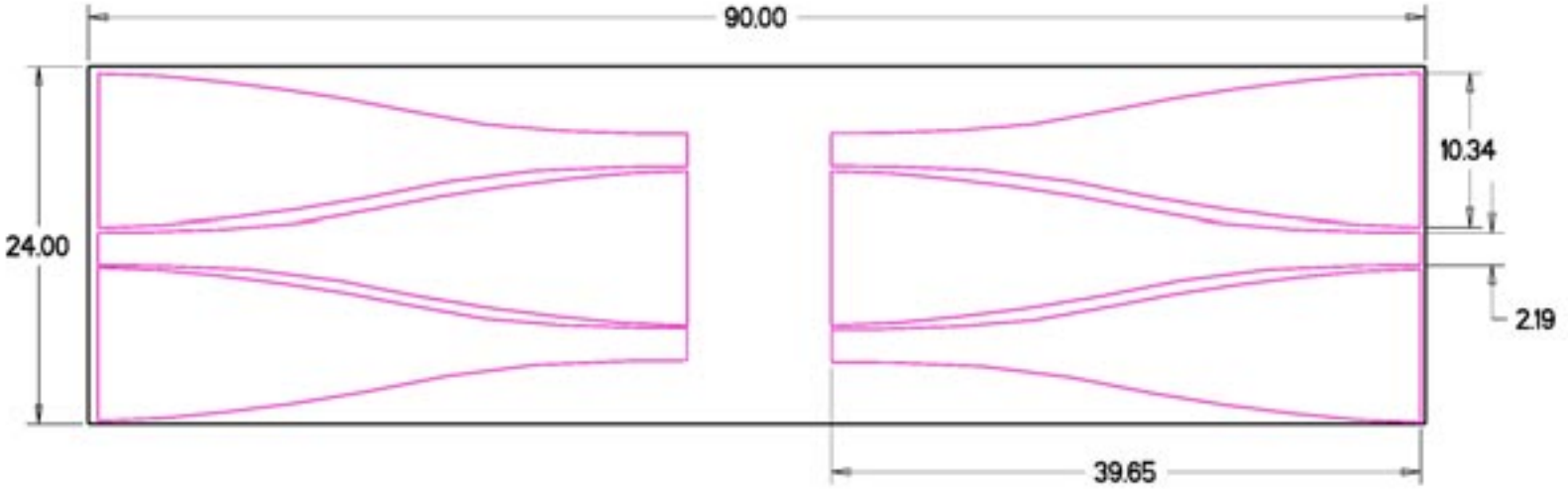
First 2’ x 8’ sheet of bonded SS-CrCu material ordered for testing

CDX-U

LTX

- Sections to be CNCed flat with all welding, necking details
- Formed by rolling or hydraulic press
  - Simple 2D stamping; modest size (~16” x 20”)
  - Total of 28 formed sections required
- Butt weld on interior SS surface to join sections
- Support lips, necking added
- Fixturing for heaters



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